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G. C. RONAN, Director
Laboratory Services Branch

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EVALUATION OF A NEW FILTER MEDIA FOR HIGH VOLUME SAMPLING

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Comparison of Properties of Glass Fibre and Polyflon (Teflon) Filters for High Volume Analysis

INTRODUCTION

Since the introduction of the glass fibre filter, as the sampling medium for the determination of total suspended particulate (TSP) in the atmosphere, there has been little change and glass fibre has remained the tradional filter. The demands on the filter have increased with time to include the determination of toxic metals, carbon, PAH's,, sulphate, nitrate, etc. Other media have been used to combat the unsuitability of glass fibre for these analyses and these include ones fabricated from cellulose acetate, polystyrene, silica, teflon coated glass fibre membrane, etc. All these types have been incorporated into the high volume sampler (Hi-Vol) system with some success. Cellulose acetate and polystyrene are less efficient filters, and give inaccurate TSP values due to weight variation with change in relative humidity[1,2] silica and teflon coated filters reduced the sulphur dioxide/nitrogen oxide conversion to sulphate and nitrate (artifact effect), but the filters still contain a high level of impurity in their matrix background[3,4].

In any sampling program for total suspended particulate the filter medium plays an important part. Since the filter collects the particulate for future study, it should have an efficiency close to 100%, not interfere chemically with the captured particulate, have a low flow resistance, and great strength[5]. No perfect filter exists; the analyst should know what he is looking for in the collected particulate, and choose a filter medium that is minimal in its interference and maximal in its efficiency. Two types of filter exist; fibrous and membranous. This paper deals with the former.

Fibre filters are composed of fibres that are laid down as a mat, without a pore size being specified (Figure 1) and are strong, with high flow rates and high efficiencies[5]. These filters are usually made from glass or cellulose fibres and may or may not contain an organic binder for strength. Glass fibre filters are composed of fibres with a complex chemical composition but one fabricated from a polyfluorinated hydrocarbon would be chemically inert and have uniform chemical composition.

In 1984 Toyo Roshi of Japan introduced an 8 x 10 inch Hi-Volume filter fabricated from teflon fibres having collection properties similar to those of glass fibre (Figure 2). This report covers a comparison study between glass fibre (Gelman AE)[6] and polyflon at locations in Ontario, Canada and compares TSP, metals and sulphate and nitrate concentrations on the two types of filters.

METHODS

Air Sampling

With the cooperation of staff of the Central, West Central and North East Region of the Ontario Ministry of the Environment (MOE) Hi-Vols were installed in the following locations.

Location	Station	Station Numbers Glass Fibre	Polyflon
Sudbury	Copper Cliff	77070	77170
Toronto	Breadalbane St.	31104	31123 & 31124 (duplicates)
Hamilton	Barton St.	29025	29325
	Beach Blvd.	29102	29302
	Leeds & Burlington	29011	29311

A twin pack Hi-Vol sampler was operated by the Atmospheric Environmental Service (A.E.S.) of Environment Canada at Downsview using two polyflon filters held in series.

At each location filters were exposed on comparable Hi-Vol units placed some three feet apart with the exception of Breadalbane station, a daily station, where seven Hi-Vol samplers were used sequentially. The approved ASTM method was used at all locations[7]. Most units were fitted with an automatic flow controllers and sampled 1600 m^3 of air over 24 hours.

After exposure both tared filters were returned to the Ministry Laboratory, conditioned at 50% humidty for 16 hours and reweighed. The total suspended particulate was determined by the standard method[7].

Aliquots were taken from the glass fibre filters and analysed for toxic metals by the approved MOE method[8], where a section of the filter is digested in a HF/HNO_3/reaction mixture to remove excess silica, dissolved in 5% nitric acid and analysed for ten metals using atomic absorption spectrophotometry, the final results being expressed in $\mu g/m^3$.

The polyflon filters were analysed by X-ray fluorescence (XRF) by the MOE method based on the method developed for dichotomous filters[9] which determines twenty-four elements. Filters from Barton St (29025/29325) were analysed for aqueous soluble sulphate and nitrate using ion chromatography. The polyflon filter was evaluated by optical microscopy to determine structure of the filter (Figure 2) and particulate penetration. Breakthrough was assessed by AES (Canada) Downsview who exposed three sets of polyflon filters using a Hi-Vol Sampler fitted with a special filter holder that positioned one 8" x 10" filter above the second filter. Total suspended particulate was determined gravimetrically and the breakthrough of heavy metals by XRF[9].

RESULTS AND DISCUSSION

In order to compare the properties of the two types of filter, only pollutants found in significant concentrations were studied. These included total suspended particulate, iron, lead, manganese and copper, at all stations, and also nickel at the Copper Cliff station. The results are presented in Tables I to VII in the Appendix.

The data from glass fibre and polyflon filters were analysed to determine the slope, intercept and correlation.

A summary of these results for TSP is given below in Table VIII.

Table VIII. Total suspended particulate statistics $\mu g/m^3$.

Location	Station (# Samples)	Range	Mean Glass	 Polyn	Slope	Intercept	Corr. Coeff.
Sudbury	Copper Cliff (33)	5 - 81	37	31	0.88	0.3	0.946
Hamilton	Barton & (35) Wentworth	25 - 217	93	93	0.970	1.9	0.912
	Beach Blvd. (28)	30 - 238	93	94	0.977	2.4.	0.819
	Leeds & (18) Burlington	81 - 386	157	177	0.960	26.8	0.941
Toronto	Breadalbane						
	31104-21123 (16)	17 - 101	58	44	0.53	16.4	0.592
	31104-31124 (16)	17 - 101	58	43	0.46	7.8	0.812
Duplicate	polyflon (17)	17 - 78	--	44/43	0.926	3.4	0.883
US Reproducibility Study (11) Ave. 10 from 25 locations			--	--	0.856	11.3	0.967

The glass fibre data for the Toronto station at Breadalbane St. were taken from the daily station filter rather than one dedicated to the study. The station operates seven Hi-Vol samplers sequentially and this means that the polyflon filters were compared to filters exposed on different samplers, that may be subjected to a passive loading[10]. This could be as high as 3 $\mu g/m^3$/per day.

The duplicate polyflon filters run side by side on dedicated Hi-Vol samplers show closer agreement for TSP. The samplers operated in Hamilton and Sudbury also show good agreement.

Glass fibre filters show higher TSP levels due to the artifact effect of sulphur dioxide and oxides of nitrogen[3,4] being converted to sulphate and nitrate on passage through the glass fibre filter. This effect is reduced by such media as silica or teflon. Samples of duplicate polyflon and glass fibre filters exposed at Barton and Wentworth Hamilton, were extracted with double distilled water and analysed on a Wescan Ion Chromatograph using a 269-0133 anion column. The results are given in Table IX. It was found that the sulphate level on the polyflon filter averaged 42% less than the glass fibre and the nitrate 45% less. Plots of sulphate and nitrate values on the two filter types are given in Figures 3 and 4.

It was found that at TSP levels less than 90 µg/m³ the polyflon filter recorded a lower TSP than glass fibre but above that level the TSP loading on the polyflon increased proportionally more than the glass fibre. The glass fibre TSP in ascending values was plotted against the polyflon values for the Beach Blvd. station and this effect is shown in Figure 5. This occurrance is due mainly to the artifact effect which is normally independent of the TSP loading.

Heavily loaded glass fibre and polyflon filters from this station were examined microscopically. A particle count of the two filters showed a greater number on the polyflon filter indicating a higher efficiency.

A reproducibility study of the Hi-Vol sampling method, under standard conditions was carried out by Clements et al.[11] who operated bi-weekly paired samplers. The average of each TSP value was taken as the best estimate of the true value, and half the difference between each pair of samples represents the deviation of the pair from the true value. A cumulative distribution of the individual percent deviations from the corresponding true values shows that half the mesurements differ from their true value by less than -/+4.5%. 90% of the measurements differ from the true value by less than 1/+ 14%. The quoted results have been plotted and the regression curve determined. These results are included in Table VIII and are similar to those obtained from the polyflon study.

The breakthrough studies, carried out by exposing two polyflon filters in series indicate high collection efficiences.

No metals were detected on the backup filter. The results for TSP, iron, lead, calcium and aluminum are given below in Table X.

Table X. Polyflon breakthrough studies.

Sample #	Air Vol m³	TSP		% Diff.	Fe		Pb		Ca		Al	
		Top	Bot.		Top	Bot.	Top	Bot.	Top	Bot.	Top	Bot.
1	1706	15.6	.2	1.1	.36	nd	.04	nd	.8	nd	.3	nd
2	2438	34.9	1.3	3.6	.55	nd	.12	nd	1.2	nd	.5	nd
3	3690	21	.3	1.4	.33	nd	.04	nd	.6	nd	.4	nd

The regression curves for the five studied metals were determined from the data in Tables I to VII and reported in table form in Tables XI to XV.

Table XI. Iron regression results. µg/m³

Location	Station	Range	Mean		Slope	Intercept	Corr. Coeff.
			Glass	Polyn			
Sudbury	Copper Cliff	0.2 - 8.4	1.8	1.4	0.97	0.56	0.98
Hamilton	Barton & Wentworth	0.4 - 17.8	3.6	3.7	1.00	0.15	0.98
	Beach Blvd.	0.5 - 21.3	4.7	5.6	0.82	1.1	0.73
	Leeds & Burlington	2.6 - 22.9	9.0	9.4	0.96	0.75	0.95
Toronto	Breadabane	0.3 - 1.6	0.6	0.7	1.05	0.13	0.89
	Breadalbane	0.3 - 1.6	0.6	0.6	0.95	0.08	0.95
	Duplicates	0.3 - 1.6	0.7	0.6	1.04	0.05	0.91

These results show an acceptable correlation, and at higher TSP's the improved efficiency of the polyflon is reflected in the higher average iron values. The glass fibre filter iron values may also show a bias due to high blanks.

Table XII. Lead regression results. µg/m³

Location	Station	Range	Mean		Slope	Intercept	Corr. Coeff.
			Glass	Polyn			
Sudbury	Copper Cliff	0.03 - 0.6	0.15	0.12	0.94	0.02	0.98
Hamilton	Barton & Wentworth	0.1 - 0.8	0.28	0.26	0.88	0.01	0.91
	Beach Blvd.	0.1 - 0.6	0.2	0.25	1.19	0.0	0.79
	Leeds & Burlington	0.1 - 0.5	0.24	0.31	1.05	0.02	0.74
Toronto	Breadalbane	0.06 - 0.5	0.2	0.13	0.63	0.03	0.86
	Breadalbane	0.06 - 0.5	0.16	0.15	0.79	0.02	0.87
	Duplicates	0.06 - 0.5	0.13	0.15	1.23	0.01	0.92

The lead values are running close to the detection limit and the correlation is acceptable under these conditions.

Table XIII. Manganese regression results. $\mu g/m^3$

Location	Station	Range	Mean		Slope	Intercept	Corr. Coeff.
			Glass	Polyn			
Sudbury	Copper Cliff	0.01 - 0.06	0.02	0.02	0.89	0.01	0.62
Hamilton	Barton & Wentworth	0.03 - 0.77	0.25	0.21	0.78	0.01	0.96
	Beach Blvd.	0.03 - 0.85	0.36	0.27	0.44	0.08	0.69
	Leeds & Burlington	0.22 - 1.3	0.63	0.52	0.87	0.03	0.85
Toronto	Breadalbane	0.01 - 0.07	0.02	0.03	0.75	0.01	0.75
	Breadalbane	0.01 - 0.07	0.02	0.03	0.71	0.01	0.79
	Duplicates	0.01 - 0.07	0.03	0.03	0.93	0.0	0.77

The manganese levels, like lead, are close to the detection limit and can be considered acceptable.

Table XIV. Copper regression results. $\mu g/m^3$

Location	Station	Range	Mean		Slope	Intercept	Corr. Coeff.
			Glass	Polyn			
Sudbury	Copper Cliff	0.05 - 9.9	1.1	0.8	0.71	0.0	0.99
Hamilton	Barton & Wentworth	0.03 - 0.38	0.15	0.13	0.48	0.05	0.47
	Beach Ave.	0.04 - 1.1	0.19	0.36	0.06	0.34	0.02
	Leeds & Burlington	0.02 - 3.4	0.34	0.31	0.83	0.27	0.78
Toronto	Breadalbane	0.01 - 1.6	0.22	0.06	0.3	0.02	0.64
	Breadalbane	0.01 - 1.6	0.22	0.26	0.87	0.05	0.80
	Duplicates	0.01 - 1.6	0.06	0.26	3.55	0.05	0.68

The copper results illustrate very well the effect of worn commutators on the Hi-Vol motors; the duplicate polyflon filters show a wide mean variation. The Copper Cliff station has a higher copper level & shows an improved correlation coefficient.

Table XV. Nickel regression results. $\mu g/m^3$

Location	Station	Range	Mean		Slope	Intercept	Corr. Coeff.
			Glass	Polyn			
Sudbury	Copper Cliff	0.01 - 1.6	0.42	0.43	0.90	0.03	0.98

Only at Copper Cliff were the data high enough to evaluate statistically and are within acceptable levels.

Conclusions

Polyflon provides a filter medium with similar flow properties to glass fibre, as well as high efficiency for all particulates. It is chemically inert with respect to all gases, suffers little pressure drop, and has no severe clogging or hydroscopic problems.

The advantages of polyflon are:

(a) The artifact effect for SO_2 and NO_x is reduced, thus providing a more accurate TSP.

(b) XRF on polyflon will provide 24 elements with one analysis. (Elements commonly determined on glass fibre: iron, manganese, cadmium, chromium, arsenic (11), phosphorus, bromine, chlorine, copper, nickel, lead, selenium, vanadium and zinc need to be analysed by several techniques. XRF on polyflon provides, in addition: aluminum, barium, calcium, potassium, rubidium, silicon, strontium, sulphur, titanium and zirconium.)

The analytical techniques for glass fibre filter samples are labour intensive, costly and susceptible to high blank corrections. The polyflon filter has a low level of metal impurities and very little blank correction is required.

Disadvantages

The filter is expensive, approximately ten times that of glass fibre and free and total carbon cannot be analysed. When all toxic metals are required the polyflon filter has a cost advantage but it is impractical for TSP analysis only.

Future plans

Four comparison Hi-Volume stations at Toronto, Hamilton, Sudbury and London will be maintained throughout 1987 and, on recommendation of this study, the glass fibre filter may be phased out in the Ontario Hi-Vol network in 1988. Possibly the best future combination will be size selective inlet and polyflon filters.

Other possible uses include determination of the Pb contribution from industrial versus automobile sources by measuring the Pb/Br ratio, and utilization in Lo-Vol sequential samplers.

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Figure 1. Glass fibre (Gelman AE) x30.

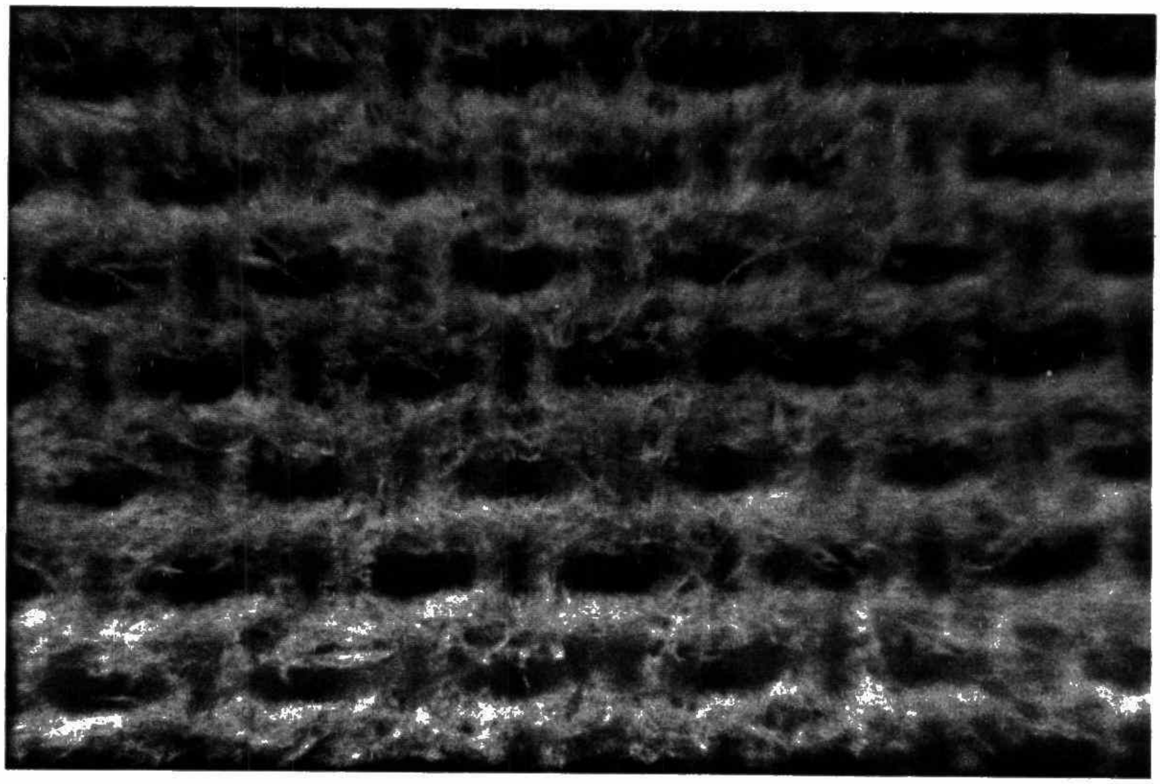

Figure 2. Polyflon x30.

APPENDIX

Table I. Analytical Data from Copper Cliff, Sudbury

DATE	STATION 77070 77170 COPPER CLIFF SUDBURY ug/M^3											
	TSP		Fe		Pb		Cu		Mn		Ni	
	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON
Dec 12 85	19	12	0.20	0.22	0.10	0.03	0.32	0.15	0.01	0.01	0.07	0.09
Jan 2 86	39	12	1.00	1.20	0.40	0.38	5.20	4.50	0.01	0.02	1.50	1.60
Jan 8 86	27	21	1.50	1.40	0.10	0.10	0.38	0.26	0.01	0.01	0.16	0.20
Jan 14 86	34	23	0.80	0.73	0.20	0.14	0.63	0.37	0.01	0.01	0.25	0.27
Jan 20 86	13	7	0.20	0.96	0.10	0.03	0.23	0.17	0.01	0.01	0.08	0.22
Feb 1 86	25	16	0.30	0.36	0.10	0.12	0.39	0.24	0.01	0.00	0.27	0.27
Feb 7 86	84	61	3.90	3.10	0.80	0.64	9.90	6.50	0.04	0.03	2.30	2.20
Feb 13 86	22	16	0.70	1.00	0.10	0.05	0.22	0.11	0.01	0.01	0.05	0.07
Feb 19 86	45	26	0.80	0.56	0.40	0.20	1.80	1.50	0.01	0.01	1.20	1.20
Feb 25 86	44	46	2.30	2.60	0.20	0.20	1.05	1.07	0.01	0.03	0.83	1.04
Mar 3 86	29	34	0.70	1.30	0.10	0.10	0.43	0.49	0.01	0.02	0.16	0.35
Mar 9 86	19	13	0.20	0.35	0.10	0.03	0.15	0.08	0.01	0.01	0.04	0.04
Mar 15 86	16	9	0.30	0.20	0.10	0.10	0.51	0.30	0.02	0.00	0.54	0.29
Mar 21 86	34	33	1.60	1.10	0.10	0.03	0.19	0.12	0.01	0.02	0.08	0.09
Mar 27 86	29	29	0.70	0.70	0.10	0.10	0.30	0.20	0.01	0.01	0.16	0.14
Apr 2 86	57	56	3.10	2.60	0.10	0.10	1.30	1.00	0.02	0.03	0.57	0.60
Apr 8 86	7	5	0.30	0.20	0.03	0.01	0.14	0.04	0.02	0.00	0.03	0.01
May 2 86	67	70	8.40	6.10	0.10	0.03	0.29	0.15	0.05	0.06	0.21	0.18
May 8 86	66	62	4.70	4.40	0.26	0.33	5.80	4.40	0.03	0.05	1.40	1.60
May 14 86	83	81	2.70	2.50	0.10	0.10	0.65	0.44	0.03	0.04	0.39	0.49
May 20 86	60	35	3.90	2.60	0.20	0.13	1.60	0.90	0.02	0.02	1.60	1.30
May 26 86	60	53	2.90	2.30	0.10	0.10	1.10	0.70	0.02	0.03	0.54	0.53
Jun 1 86	28	26	1.00	0.80	0.10	0.05	0.60	0.40	0.01	0.01	0.26	0.22
Jun 7 86	40	41	1.10	1.10	0.10	0.10	0.56	0.42	0.01	0.03	0.42	0.47
Jun 13 86	28	30	0.90	1.00	0.10	0.10	0.62	0.59	0.01	0.02	0.31	0.32
Jun 19 86	34	37	1.50	1.80	0.10	0.10	0.34	0.21	0.03	0.04	0.09	0.14
Jun 25 86	20	19	1.00	0.80	0.10	0.03	0.26	0.08	0.02	0.01	0.07	0.06
Jul 1 86	18	19	0.60	0.60	0.10	0.10	0.30	0.20	0.01	0.01	0.06	0.08
Jul 7 86	38	38	2.40	1.80	0.10	0.10	0.35	0.12	0.02	0.04	0.06	0.07
Jul 13 86	16	14	0.60	0.50	0.10	0.10	0.14	0.07	0.01	0.01	0.02	0.04
Jul 19 86	28	27	2.00	0.50	0.10	0.10	0.25	0.12	0.01	0.01	0.04	0.05
Jul 25 86	55	44	3.60	1.00	0.10	0.05	0.16	0.12	0.01	0.03	0.06	0.07
Jul 31 86	24	16	2.10	0.60	0.10	0.10	0.12	0.05	0.01	0.01	0.04	0.03
SUM	1208	1031	58.00	46.98	4.99	3.98	36.28	26.07	0.53	0.66	13.85	14.33
MEAN	36.6	31.2	1.76	1.42	0.15	0.12	1.10	0.79	0.02	0.02	0.42	0.43
STD DEV	19.6	19.0	1.69	1.27	0.14	0.12	2.00	1.44	0.01	0.01	0.55	0.54

Table II. Analytical Data from Barton & Wenthworth, Hamilton.

STATION 29025 29325 BARTON & WENTWORTH HAMILTON

DATE	TSP		Fe		Pb		Cu		Mn	
	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON
Jan 18 86	64	63	0.40	0.50	0.20	0.20	0.09	0.01	0.06	0.03
Jan 23 86	104	100	3.20	4.00	0.40	0.40	0.11	0.15	0.43	0.33
Jan 28 86	60	59	0.90	1.00	0.20	0.15	0.03	0.04	0.05	0.05
Feb 1 86	84	74	2.20	2.20	0.30	0.30	0.09	0.15	0.13	0.09
Feb 12 86	72	63	1.00	1.00	0.30	0.30	0.05	0.12	0.08	0.06
Feb 16 86	52	45	1.60	1.00	0.20	0.10	0.07	0.13	0.09	0.05
Feb 18 86	101	96	6.00	4.00	0.80	0.50	0.13	0.14	0.40	0.18
Feb 22 86	61	53	4.50	3.60	0.20	0.20	0.13	0.04	0.23	0.15
Mar 2 86	107	89	1.30	1.20	0.40	0.30	0.20	0.15	0.08	0.06
Mar 5 86	74	81	2.30	2.60	0.20	0.20	0.15	0.09	0.15	0.14
Mar 8 86	70	64	0.80	0.90	0.20	0.20	0.06	0.09	0.06	0.05
Mar 11 86	110	93	3.20	3.90	0.20	0.30	0.11	0.08	0.22	0.21
Mar 15 86	95	90	1.60	1.70	0.30	0.30	0.11	0.09	0.15	0.11
Mar 18 86	164	166	7.20	8.50	0.50	0.50	0.20	0.20	0.77	0.54
Mar 21 86	83	148	1.50	1.80	0.20	0.20	0.07	0.07	0.09	0.10
Mar 25 86	124	136	2.40	3.60	0.10	0.30	0.12	0.08	0.20	0.20
Mar 28 86	74	83	1.70	1.80	0.20	0.10	0.08	0.09	0.09	0.09
Apr 5 86	103	106	8.90	9.60	0.20	0.20	0.19	0.13	0.84	0.63
Apr 9 86	30	40	0.60	1.00	0.10	0.10	0.13	0.06	0.03	0.04
Apr 12 86	36	32	0.70	0.80	0.10	0.02	0.16	0.08	0.05	0.04
Apr 17 86	226	217	12.20	12.20	0.60	0.70	0.30	0.20	0.77	0.61
Apr 20 86	89	88	5.50	7.00	0.20	0.20	0.19	0.13	0.34	0.31
Apr 23 86	92	96	3.80	5.20	0.20	0.20	0.20	0.12	0.36	0.36
Apr 29 86	80	84	2.90	2.40	0.30	0.20	0.10	0.10	0.18	0.12
May 3 86	60	76	1.30	1.60	0.10	0.10	0.15	0.08	0.06	0.07
May 6 86	113	120	2.90	3.10	0.20	0.20	0.12	0.08	0.15	0.13
May 17 86	73	70	1.40	1.40	0.20	0.20	0.18	0.15	0.09	0.08
May 22 86	104	104	3.60	4.10	0.40	0.40	0.17	0.15	0.21	0.22
May 25 86	77	80	4.90	4.80	0.20	0.20	0.30	0.20	0.30	0.30
Jun 5 86	153	147	11.20	11.10	0.70	0.70	0.24	0.23	0.77	0.69
Jun 8 86	41	39	1.30	1.20	0.10	0.10	0.17	0.07	0.07	0.07
Jun 10 86	275	255	16.80	17.80	0.60	0.60	0.25	0.32	1.00	1.00
Jun 13 86	71	74	2.00	1.30	0.20	0.10	0.15	0.12	0.12	0.06
Jun 19 86	75	68	1.70	1.80	0.30	0.30	0.14	0.38	0.09	0.09
Jun 25 86	50	40	1.30	1.50	0.20	0.20	0.23	0.23	0.05	0.06
SUM	3247	3239	124.80	131.20	9.80	9.27	5.17	4.55	8.76	7.32
MEAN	92.8	92.5	3.57	3.75	0.28	0.26	0.15	0.13	0.25	0.21
STD DEV	48.6	47.4	3.64	3.81	0.17	0.16	0.07	0.08	0.26	0.22

Table III. Analytical data from Beach Blvd., Hamilton

DATE	STATION 29102	29302 BEACH BLVD HAMILTON			ug/M^3					
	TSP		Fe		Pb		Cu		Mn	
	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON
Jan 18 86	85	85	3.30	3.40	0.30	0.30	0.19	0.86	0.21	0.14
Jan 21 86	137	87	8.50	5.80	0.30	0.30	0.23	0.76	0.57	0.27
Jan 28 86	134	215	6.70	10.60	0.20	0.30	0.13	1.10	0.54	0.49
Jan 30 86	132	177	4.90	11.40	0.20	0.30	0.11	0.65	0.38	0.51
Feb 1 86	87	61	1.20	0.90	0.10	0.10	0.13	0.39	0.15	0.05
Feb 12 86	200	238	11.70	18.30	0.20	0.50	0.18	0.40	0.99	0.74
Feb 15 86	174	135	11.90	10.80	0.20	0.30	0.04	0.28	1.04	0.42
Feb 19 86	74	54	1.10	0.60	0.20	0.20	0.24	0.68	0.13	0.03
Feb 22 86	38	31	1.10	1.20	0.10	0.10	0.13	0.28	0.09	0.07
Mar 1 86	180	188	18.50	21.30	0.30	0.60	0.10	0.50	1.50	1.00
Mar 4 86	105	148	4.60	6.40	0.20	0.30	0.17	0.43	0.48	0.36
Mar 28 86	82	81	4.10	4.20	0.20	0.10	0.14	0.22	0.21	0.18
Apr 5 86	26	25	0.70	0.70	0.10	0.10	0.07	0.04	0.06	0.06
Apr 9 86	40	29	1.70	1.30	0.10	0.10	0.24	0.21	0.19	0.12
Apr 12 86	60	49	3.30	3.10	0.10	0.10	0.12	0.23	0.44	0.27
Apr 15 86	35	37	0.80	0.70	0.10	0.10	0.10	0.09	0.08	0.04
Apr 19 86	77	72	4.70	5.80	0.10	0.10	0.17	0.18	0.29	0.25
Apr 24 86	220	201	12.40	14.10	0.50	0.70	0.33	0.40	0.85	0.72
Apr 29 86	115	183	5.70	12.00	0.20	0.40	0.22	0.45	0.36	0.53
May 10 86	66	59	1.90	1.70	0.30	0.30	0.23	0.29	0.12	0.07
May 14 86	52	41	1.30	0.60	0.10	0.10	0.38	0.21	0.05	0.02
May 27 86	70	77	1.90	2.40	0.20	0.20	0.19	0.25	0.15	0.15
May 31 86	72	63	3.10	2.30	0.10	0.10	0.16	0.12	0.21	0.13
Jun 5 86	61	36	1.70	0.50	0.10	0.10	0.21	0.10	0.10	0.03
Jun 10 86	43	37	1.60	1.50	0.10	0.20	0.27	0.28	0.11	0.07
Jun 14 86	69	60	5.20	7.00	0.30	0.30	0.36	0.27	0.46	0.51
Jun 20 86	45	35	1.90	2.00	0.30	0.30	0.38	0.23	0.12	0.11
Jun 26 86	117	123	5.10	6.00	0.30	0.30	0.11	0.19	0.26	0.29
SUM	2596	2627	130.6	156.6	5.5	6.9	5.33	10.09	10.14	7.63
MEAN	92.7	93.8	4.66	5.59	0.20	0.25	0.19	0.36	0.36	0.27
STD DEV	51.2	63.8	4.27	5.59	0.10	0.16	0.09	0.25	0.35	0.25

Table IV. Analytical data from Burlington & Leeds. Hamilton.

DATE	STATION 29011	29311 BURLINGTON & LEEDS HAMILTON			ug/M^3					
	TSP		Fe		Pb		Cu		Mn	
	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON
Feb 1 86	123	105	5.30	5.20	0.20	0.20	0.15	0.20	0.52	0.27
Feb 7 86	115	164	6.10	6.80	0.20	0.20	0.09	0.10	0.91	0.38
Feb 13 86	87	92	3.70	2.70	0.20	0.20	0.07	0.08	0.48	0.24
Feb 19 86	114	137	7.30	7.70	0.40	0.50	0.16	0.20	0.49	0.36
Feb 25 86	110	162	5.10	6.40	0.20	0.30	0.10	0.18	0.60	0.50
Mar 3 86	222	265	10.80	11.60	0.40	0.50	0.21	0.28	1.10	0.70
Mar 9 86	120	127	7.00	7.50	0.10	0.20	0.12	0.17	0.39	0.31
Mar 21 86	136	121	3.40	3.00	0.20	0.20	0.11	0.14	0.36	0.23
Mar 27 86	112	105	4.30	3.40	0.30	0.20	0.11	0.13	0.39	0.24
Apr 8 86	81	112	2.60	4.80	0.20	0.30	0.11	0.12	0.35	0.40
Apr 20 86	123	131	7.10	8.70	0.10	0.10	0.22	0.15	0.44	0.44
Apr 26 86	341	315	22.90	18.40	0.60	0.70	0.30	0.22	1.30	1.00
May 2 86	87	144	2.60	4.10	0.20	0.20	0.16	0.11	0.33	0.34
May 8 86	195	229	18.60	18.70	0.30	0.50	0.38	0.34	0.88	0.75
May 14 86	332	386	24.90	26.40	0.20	0.50	3.40	2.80	1.00	1.30
May 20 86	85	85	6.70	5.70	0.20	0.20	0.02	0.04	0.26	0.22
May 26 86	311	308	19.30	20.90	0.20	0.40	0.21	0.26	1.20	1.30
Jun 1 86	128	204	5.60	6.80	0.10	0.10	0.17	0.14	0.37	0.41
SUM	2822	3192	162.3	168.9	4.3	5.5	6.09	5.66	11.37	9.39
MEAN	156.8	177.3	9.02	9.38	0.24	0.31	0.34	0.31	0.63	0.52
STD DEV	94.1	85.7	6.90	6.77	0.12	0.16	0.75	0.61	0.33	0.38

Table V. Analytical data from Breadalbane St., Toronto.

STATION 31104 31123 BREADALBANE St. TORONTO ug/M^3

DATE	TSP		Fe		Pb		Cu		Mn	
	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON
Feb 10 86	39	29	0.20	0.29	0.20	0.12	0.10	0.01	0.02	0.01
Feb 13 86	82	48	0.60	0.62	0.10	0.08	1.60	0.02	0.02	0.02
Feb 16 86	52	30	0.30	0.36	0.10	0.08	0.10	0.01	0.02	0.01
Feb 19 86	57	33	0.30	0.35	0.30	0.20	0.22	0.02	0.02	0.02
Feb 22 86	42	25	0.40	0.40	0.10	0.06	0.05	0.01	0.01	0.01
Feb 26 86	75	44	0.20	0.83	0.10	0.13	0.15	0.03	0.01	0.03
Mar 6 86	24	20	0.20	0.22	0.10	0.06	0.06	0.01	0.01	0.01
Mar 9 86	45	30	0.20	0.29	0.10	0.05	0.03	0.02	0.01	0.02
Mar 12 86	68	37	0.70	0.72	0.10	0.10	0.10	0.02	0.02	0.02
Mar 15 86	57	41	0.30	0.72	0.20	0.20	0.17	0.03	0.01	0.03
MAR 18 86	101	78	1.20	1.35	0.20	0.16	0.21	0.05	0.04	0.05
Mar 21 86	70	53	0.80	0.90	0.10	0.11	0.13	0.03	0.02	0.03
Mar 27 86	72	61	1.00	1.20	0.20	0.17	0.23	0.05	0.04	0.05
Apr 5 86	35	30	0.40	0.51	0.10	0.06	0.03	0.03	0.02	0.03
Apr 11 86	29	46	0.50	0.97	0.10	0.14	0.14	0.03	0.01	0.03
Apr 26 86	83	74	1.80	0.53	0.50	0.32	0.26	0.05	0.07	0.05
SUM	931	679	9.10	10.26	2.60	2.04	3.58	0.42	0.35	0.42
MEAN	58.2	42.4	0.57	0.64	0.16	0.13	0.22	0.03	0.02	0.03
STD DEV	21.1	16.5	0.43	0.33	0.11	0.07	0.36	0.01	0.02	0.01

Table VI. Analytical data from Breadalbane St., Toronto.

STATION 31104 31124 BREADALBANE St. TORONTO ug/M^3

DATE	TSP		Fe		Pb		Cu		Mn	
	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON	GLASS	POLYFLON
Feb 10 86	39	28	0.20	0.29	0.20	0.19	0.10	0.36	0.02	0.02
Feb 13 86	82	48	0.60	0.56	0.10	0.12	1.60	0.26	0.02	0.02
Feb 16 86	52	31	0.30	0.36	0.10	0.10	0.10	0.26	0.02	0.01
Feb 19 86	57	52	0.30	0.30	0.30	0.20	0.22	0.38	0.02	0.02
Feb 22 86	42	20	0.40	0.32	0.10	0.07	0.05	0.06	0.01	0.01
Feb 26 86	75	49	0.20	1.12	0.10	0.20	0.15	0.20	0.01	0.04
Mar 6 86	24	17	0.20	0.22	0.10	0.02	0.06	0.03	0.01	0.01
Mar 9 86	45	32	0.20	0.33	0.10	0.07	0.03	0.06	0.01	0.01
Mar 12 86	68	47	0.70	0.74	0.10	0.10	0.10	0.08	0.02	0.03
Mar 15 86	57	46	0.30	0.46	0.20	0.15	0.17	0.29	0.01	0.02
MAR 18 86	101	71	1.20	1.41	0.20	0.18	0.21	0.24	0.04	0.05
Mar 21 86	70	50	0.80	0.85	0.10	0.10	0.13	0.25	0.02	0.03
Mar 27 86	72	57	1.00	1.10	0.20	0.14	0.23	0.34	0.04	0.04
Apr 5 86	35	30	0.40	0.52	0.10	0.09	0.03	0.15	0.02	0.02
Apr 11 86	29	45	0.50	1.05	0.10	0.17	0.14	0.52	0.01	0.03
Apr 26 86	83	82	1.80	1.56	0.50	0.46	0.26	0.63	0.07	0.06
SUM	931	705	9.10	11.19	2.60	2.36	3.58	4.11	0.35	0.42
MEAN	58.2	44.1	0.57	0.70	0.16	0.15	0.22	0.26	0.02	0.03
STD DEV	21.1	16.9	0.43	0.42	0.11	0.10	0.36	0.16	0.02	0.01

Table VII. Duplicate polyflon data.

DATE	STATION 31123 TSP		31124 BREADALBANE St. Fe		TORONTO Pb		ug/M^3 Cu		Mn	
	POLYF A	POLYF B	POLYF A	POLYF B	POLYF A	POLYF B	POLYF A	POLYF B	POLYF A	POLYF B
Feb 10 86	29	28	0.29	0.29	0.12	0.19	0.05	0.36	0.01	0.02
Feb 13 86	48	48	0.62	0.56	0.08	0.12	0.04	0.26	0.02	0.02
Feb 16 86	30	31	0.36	0.36	0.08	0.10	0.05	0.26	0.01	0.01
Feb 19 86	33	52	0.35	0.30	0.20	0.20	0.01	0.38	0.02	0.02
Feb 22 86	25	20	0.40	0.32	0.06	0.07	0.03	0.06	0.01	0.01
Feb 26 86	44	49	0.83	1.12	0.13	0.20	0.07	0.20	0.03	0.04
Feb 28 86	50	31	0.70	0.40	0.13	0.08	0.06	0.05	0.02	0.02
Mar 6 86	20	17	0.22	0.22	0.06	0.02	0.02	0.03	0.01	0.01
Mar 9 86	30	32	0.29	0.33	0.05	0.07	0.04	0.06	0.02	0.01
Mar 12 86	37	47	0.72	0.74	0.10	0.10	0.05	0.08	0.02	0.03
Mar 15 86	41	46	0.72	0.46	0.20	0.15	0.08	0.29	0.03	0.02
MAR 18 86	78	71	1.35	1.41	0.16	0.18	0.06	0.24	0.05	0.05
Mar 21 86	53	50	0.90	0.85	0.11	0.10	0.05	0.25	0.03	0.03
Mar 27 86	61	57	1.20	1.10	0.17	0.14	0.06	0.34	0.05	0.04
Apr 5 86	30	34	0.51	0.52	0.06	0.09	0.03	0.15	0.03	0.02
Apr 11 86	46	45	0.97	1.05	0.14	0.17	0.10	0.52	0.03	0.03
Apr 26 86	74	82	1.53	1.56	0.32	0.46	0.15	0.63	0.05	0.06
SUM	729	740	11.96	11.59	2.17	2.44	0.95	4.16	0.44	0.44
MEAN	42.9	43.5	0.70	0.68	0.13	0.14	0.06	0.24	0.03	0.03
STD DEV	16.1	16.5	0.38	0.41	0.07	0.09	0.03	0.16	0.01	0.01

Table IX. Comparison of sulphate & nitrate data.

DATE	29025 SULPHATE ug/M3	and	29325 NITRATE ug/M3	
	GLASS	POLYFLON	GLASS	POLYFLON
Jan 18 86	16.6	10.8	10	5.6
Jan 23 86	12.3	6.9	3.6	2.5
Jan 28 86	6.6	2.8	2.1	0
Feb 1 86	12.5	6.9	8.6	4.7
Feb 12 86	9.7	5.3	5.3	3.3
Feb 16 86	11.4	7.5	11	4.2
Feb 18 86	21	15.5	11	7.2
Feb 22.86	11.2	6.4	3.4	1.4
Mar 5 86	13.8	8.3	8.5	5.6
Mar 8 86	9.5	5.8	2.8	2.2
Mar 11 86	15.9	6.9	4.3	2.8
Mar 15 86	19.1	9.7	13.2	6.4
Mar 18 86	23.6	15.8	10.3	3.1
Mar 21 86	7.9	4.2	3.4	2.8
Mar 25 86	11.6	6.1	5.9	2.8
Mar 28 86	8.4	5.6	7.5	3.9
Apr 5 86	18.2	11.1	3.7	3.1
Apr 9 86	6.7	1.9	0	0
Apr 17 86	13.9	7.2	2.5	3.3
Apr 20 86	15.3	8.3	6.4	3.3
SUM	265.2	153	123.5	68.2
AVERAGE	13.3	7.7	6.2	3.4
STD DEV	4.6	3.5	3.6	1.8

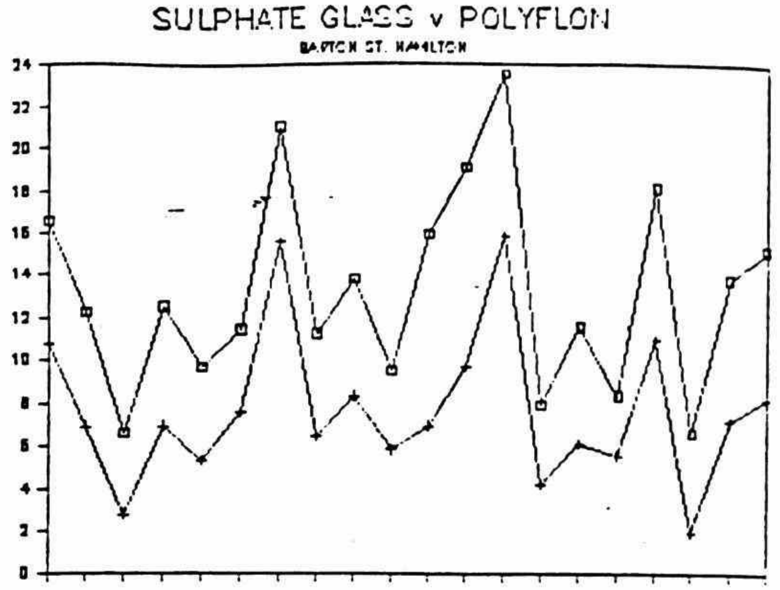

Figure 3. Comparison of sulphate.

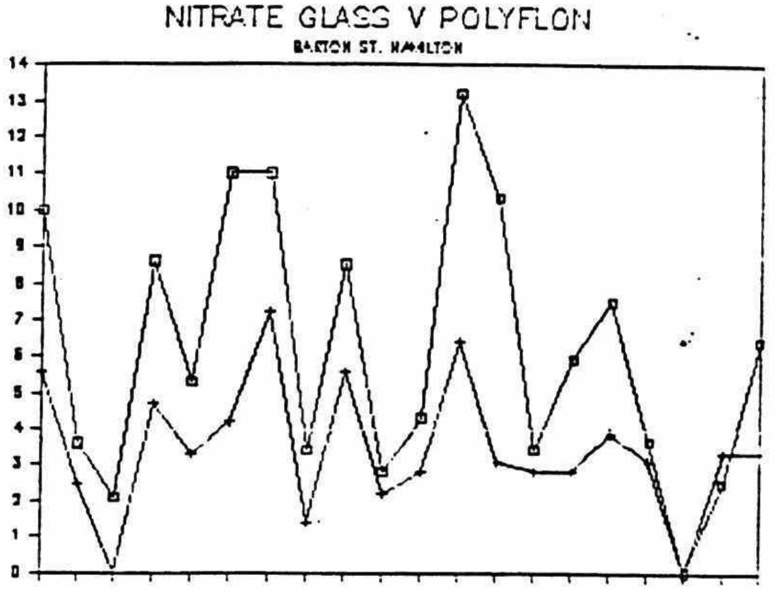

Figure 4. Comparison of nitrate.

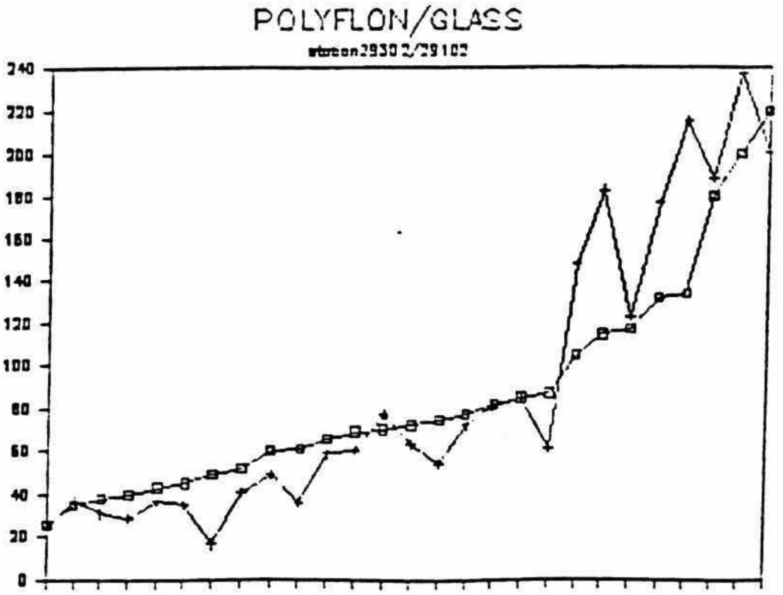

Figure 5. Plot of TSP on glass & polyflon.

□ - glass x - polyflon

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